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Controlling Harmonic of STATCOM

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Abstract: **In this paper the advantage of STATCOM to compare with SVC are presented. Due to harmonic, the method of STATCOM controller consist fixed v_{dc}, controlling by phase angle and control the modulation index and phase angle are explaimed, then the results of best controller which suit harmonic by MATLAB software are presented.**

Keywords-component; modulation index, phase angle, Synchronous static compensation (STATCOM), harmonic

I. Introduction

Compensation of reactive power in distribution and transmission networks is the basic needs in engineering. Among its objectives can be mentioned the following :

1. Releasing capacity of production, transmission and distribution
2. Improve sustainability of transport networks
3. Load balancing
4. Stabilize voltage in transmission and distribution systems
5. Power factor correction
6. Reduce losses in production , transmission and distribution

More system components require reactive power and it should be taken from network or be produced in desired location based some reasons the control of reactive power is better [1]:

1. The cost of installing expensive new equipment and Maximum utilization of existing facilities
2. Optimal operation of power systems
3. The creation of new types of static compensation

Since most industrial loads are lag and taking the reactive power, it should be produced by plant and then transported by line to the loads. These caused great losses in the network and are the limiting factor for the transmission of active power. So the compensators must be installed at loads to present the transfer extra power in line. First way of compensation in power network is applying the capacitor bank. Delay of several cycles, delivered step power and the shock voltage network are major drawbacks. The second way of compensation is used old generation FACTS devices like SVC.
Flexible Alternating Current Transmission System (FACTS) is an application of a power electronics device to control the power flow and to improve the system stability of a power system[2].
The main objective to introduce FACTS Technology is as follows:

- To increase the power transfer capability of a transmission network in a power system.

- To provide the direct control of power flow over designated transmission routes.

- To provide secure loading of a transmission lines near the thermal limits.

- To improve the damping of oscillations as this can threaten security or limit usage line capacity [3].

Defined by IEEE for FACTS are as follow [4]:
"A system based on power electronics and other static equipment that controls one or more the AC Transmission system parameters to enhance control and provide increased transmission capacity".

In the FACTS controllers, Parallel controllers can be used to solve many problems of Transmission to distribution levels. In the past decade has proven with appropriate compensation, power transmission lines increases and voltage profile along the transmission lines can be controlled. In addition, parallel controllers can improve transient stability.

With advances in power electronics, new generations of compensation mechanisms were created. This compensation is the static synchronous compensation element based on solid-state power electronics with automatic commutation to achieve control of reactive power.
Static compensation cans product or absorbed reactive power. The principle performance of static compensator is based on product or absorbed reactive power from grid. How and the amount of reactive power exchange, determined the operating point and performance of compensator [5], [6].

II. Compare STATCOM with SVC

The principles of the main operation of STATCOM and SVC are different in general. In which STATCOM is reactive power generator based on power converters that works as paralleled synchronous voltage. The basic difference between their operation results in the supremacy of STATCOM rather than SVC, in operational features, better performance and more flexibility. Since the preservation of the complete capacitors output current of the STATCOM in low voltage systems to correct the transient stability is much better than SVC.
The STATCOM not only controls reactive output power, but also produces the power in itself, and doesn’t need big capacitors, reactive banks and available protection. This results in general scale, human resource and cost reduction. The problem of STATCOM is its harmonics, since the STATCOM uses inverter in its structure and its produced voltage is the result of capacitor voltage switching, in this reason voltage output will have harmonics.
In first stage, the amounts of these harmonics in output have to be reduced or the effect of the harmonics on power network should be reached to its minimum. In order to reduce production harmonics by STATCOM, their structure or their control method have to be changed.

III. Introduce STATCOM

A. *STATCOM*

STATCOM is the first parallel controller based on power converter. The main idea was presented by Mr. Gyugyi in 1976. Due to the high switch speed power converters, STATCOM is faster than SVC. The statcom in common connection point is connected to power grids. If the compensator and network equivalent to Figure 1 , The equations governing the steady state can be written as follows:

$$P = \frac{V_S V_C \sin\alpha}{X_L} \tag{1}$$

$$Q = \frac{V_S^2 - V_S V_C \cos\alpha}{X_L} \tag{2}$$

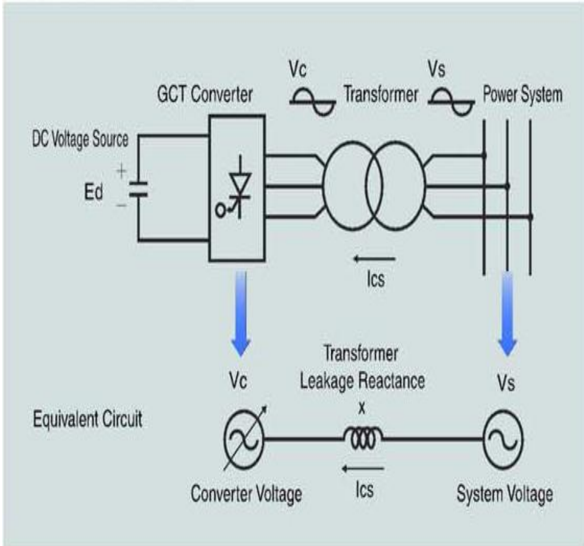

Figure 1: Single- line diagram of STATCOM

The overall structure of a STATCOM consisting of power circuit, control circuit, protection circuit and contact the system control center. Block diagram of STATCOM constituent parts and their relationship with each other show in figure 2.

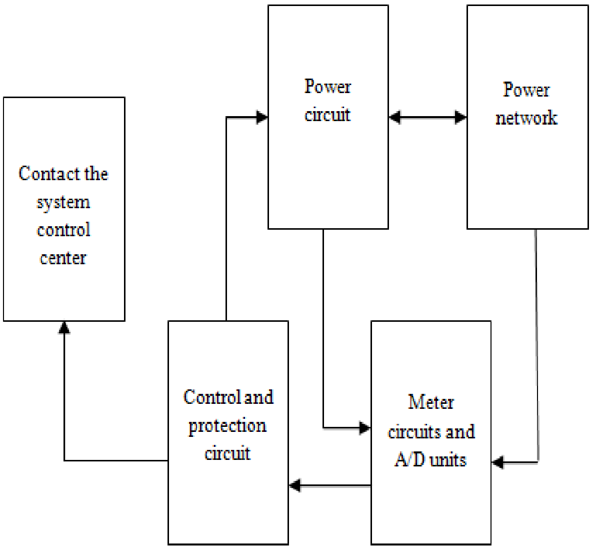

Figure 2: Block diagram of the various constituent parts of STATCOM and their relationship

B. *Orbital Model of STATCOM*

In principle STATCOM is equivalent to a synchronous condenser. Equivalent circuit and phase diagram of synchronous condenser is shown in figure 3.

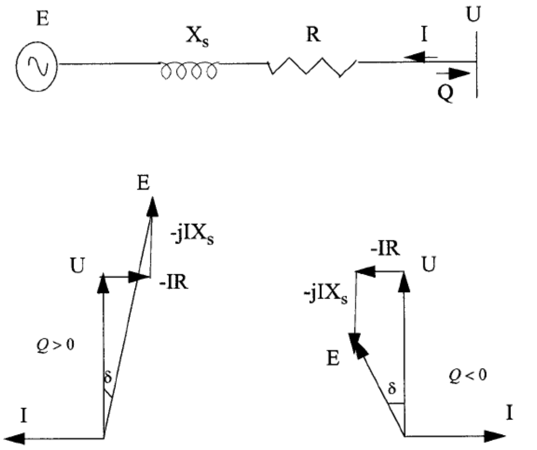

Figure 3: equivalent circuit and phase diagram of synchronous condenser [7]

IV. Static Synchronous Compensator Control Scheme

Assume that the reference signal, arbitrariness that must be produced by the reactive power compensator. In STATCOM controller design, having a good dynamic response in transient and minimum harmonics in the steady state are the necessary. Three types of control strategies for compensator based on synchronous connection can be used:

A) *Fixed v_{dc}*

In this control scheme, we keep the v_{dc} and control the reactive power with directly change in $(v_1 - v_2)$ by control modulation index. This control scheme is shown in figure 4.

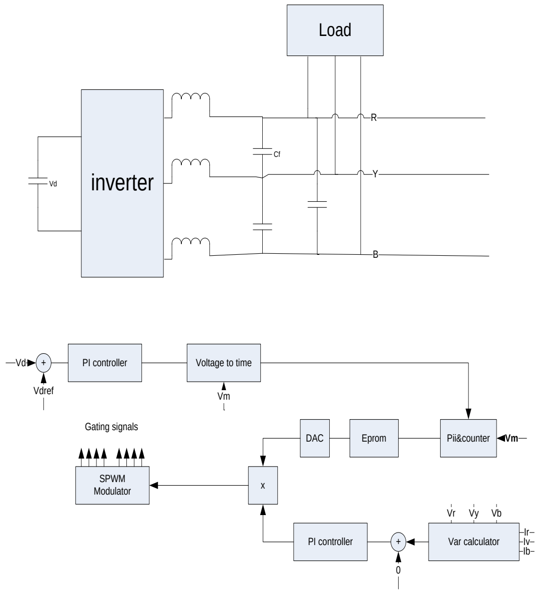

Figure 4: Static Synchronous Compensator block diagram with a constant dc voltage controls to power

B) *Control with Phase Angle*

In this way we allow that the DC voltage change and using the control angleα, reactive power produced by compensator can be controlled. This will indirectly control the reactive power. The response rate is dependant to the connecting inductance and the DC capacitor and is slower than previous method. Figure 5 shows a static compensator connected to the network in order to compensate the reactive power required [8].

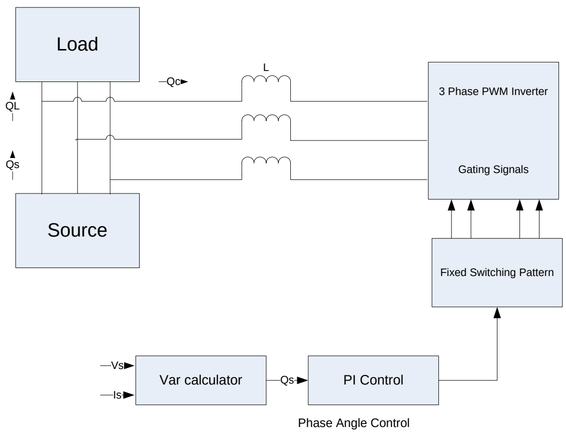

Figure 5: Block diagram of static synchronous compensator with phase angle control

C) Control with Modulation Index and Phase Angle

To improve the speed of voltage response and STATCOM reactive power output, in this scheme, both MI and phase angle are controlled [9].

This controller structure is composed of an AC voltage controller, a modulation index controller and a flow controller.

Figure 6 shows the scheme of this controller that connected to grid in MATLAB software.

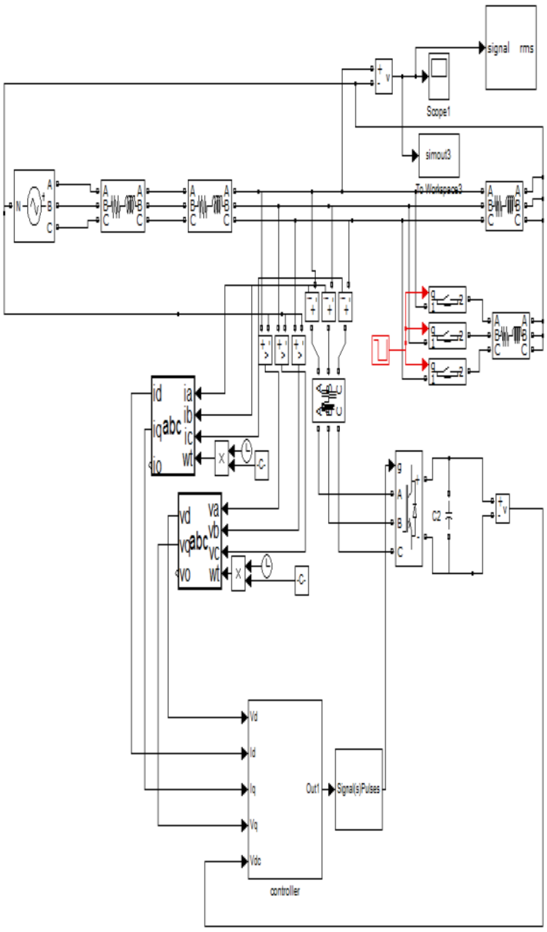

Figure 6: the schema in MATLAB

V. Simulation Results

In this part the harmonic analysis of the STATCOM controller with modulation index and phase angle is presented and additional with change in load at 0.2 second the v_{pcc} is presented.

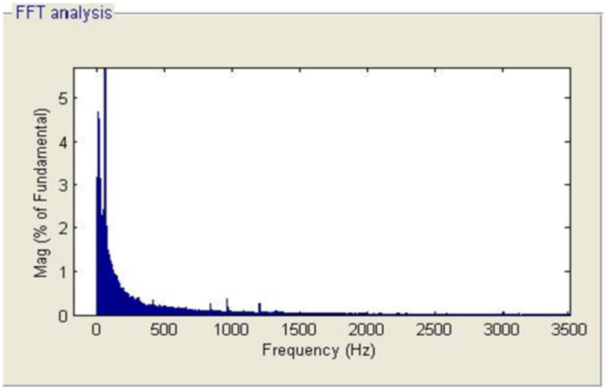

Figure7: harmonic analysis

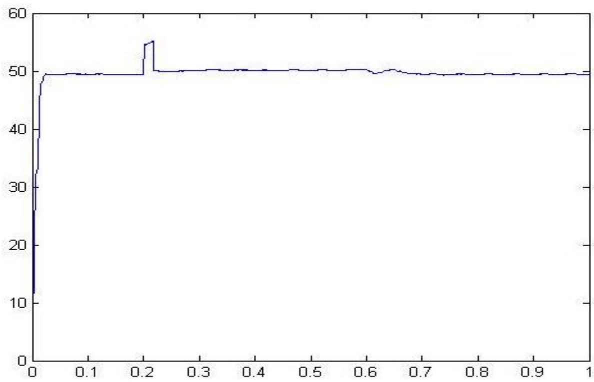

Figure 8: Vpcc (rms)

VI. Conclusion

According to what mentioned before it is understandable that STATCOM is better than SVC in performance, but it has harmonic problems which by using the proposed controller suitable amount of harmonics can be achieved.

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